REMARKS

Status of the Application

Upon entry of this amendment, Claims 1- 18are pending in this case. Claims 14-18 have been allowed. Claims 1, 4, 6, 11-13 stand rejected under 35 U.S.C. §103 (a) as allegedly being obvious over U.S. Patent 5,977,980 (*Alekscicy*) in view of U.S. Patent 5,596,686 (*Duluk, Jr.*). Claims 14-16 and 18 stand rejected under 35 U.S.C. §103(a) as allegedly being obvious over U.S. Patent 5,579,455 (*Green et al.*). Claims 2-3, 5, 7-10, stand rejected under 35 U.S.C. §103(a) as allegedly being obvious over *Alekscicy* in view of *Duluk, Jr.* and further in view of U.S. Patent 6,091,422 (*Ouaknine et al.*).

In view of the foregoing amendments and following remarks, Applicants respectfully request reconsideration of the present application and an early Notice of Allowance.

35 U.S.C. § 103(a) Rejections

Prima Facie Obviousness

To establish a *prima facie* case of obviousness, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine reference teachings. Further, there must be a reasonable expectation of success after combining the references the intended purpose of the invention is realized. **Lastly, the prior art reference (or references when combined) must teach or suggest all the claim limitations.** The teaching or suggestion to make the

claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991). Applicants respectfully submit that a *prima facie* case of obviousness has not been made for claims 1-24 of the present application.

The Present Invention

The present invention contemplates a system and methods that realize early occlusion culling. In an illustrative implementation, a graphics display screen is divided into a series of tiles arranged as a rectangular grid. The rectangular grid, or coarse Z-buffer may have various sizes and dimensions. Each tile within the coarse Z-buffer has an ***associated depth value***. Further, each tile's depth value is defined as the farther Z-buffer value that is included within the tile. In operation, the graphics pipeline is configured to update the depth values using information fed back from the Z-buffer. In an effort to maximize the effectiveness of the occlusion culling, the graphics pipeline may be configured to perform these updates on a synchronous basis. As a result, the depth values are updated each time the corresponding Z-values in the Z-buffer are changed. The ***depth values*** are stored in a location, such as main memory, where they may be available to application programs. This allows application programs to reference these values while they are creating graphics images.

Generally, the application program rendering the image constructs a surrogate volume for each object that it adds to the image. The program ***then compares the nearest Z-value of the***

surrogate volume to the depth value of the tile that includes the surrogate volume. Based on this comparison, the application program is capable of determining if the object that is being rendered is occluded and can be discarded.

Differences from *Alekiscy*

Aleksicy discloses an apparatus and method for determining visibility of a pixel during video rendering. The visibility is accomplished by determining z-positioning information of an object element that is being rendered. The z-positioning information is representative of the z-information of an object element in a particular section of the display. For example. The z-positioning information may be the two most significant bits of the z-parameter, or information of an object element. .

In contrast to the inventions of Applicants' claims 1, however, the systems and methods taught by *Aleksicy* **does not teach a system and methods that provide early occlusion culling** / **wherein a display area is modeled as a coarse z-buffer being having a make-up of tiles, wherein each tile is <u>associated a depth value, and wherein the depth value is used by applications to compare objects to be rendered so as to remove occluded objects</u>**. Rather, *Aleksicy* teaches an apparatus and method that assigns z-positioning information to object elements to be rendered in a display area. Furthermore, as Examiner states *Aleksicy* "does not explicitly disclose the coarse Z-buffer subdivide into a series of tiles." (Page 2 of Current Action). Lastly, *Aleksicy* does not provide any suggestion or teaching of the assignment of depth

values to Z-buffer tiles.

Aleksicy, alone or when combined with the prior art of record, simply does not teach or even suggest to one skilled in the use of a tiled coarse Z-buffer having associated depth values to realize occluded culling. Since *Aleksicy*, alone or when combined with the prior art of record, does not teach or suggest to one skilled in the art every limitation of the present invention, a *prima facie* case of obviousness has not been made. For these reasons, Applicants respectfully request that the obviousness rejection be withdrawn.

Differences from *Duluk*

Duluk discloses an apparatus and method for a disclose a system and method for a parallel query Z-coordinate buffer. The apparatus and method perform a keep/discard decision on screen coordinate geometry before the geometry is converted or rendered into individual display screen pixels by implementing a parallel searching technique within a novel z-coordinate buffer based on a magnitude comparison content addressable memory (MCAMM) structure. In operation, the MCAMM provides a means for performing simultaneous arithmetic magnitude comparisons on numerical quantities.

In contrast to the inventions of Applicants' claims 1, however, the systems and methods taught by *Duluk* **does not teach a system and methods that provide early occlusion culling wherein a display area is modeled as a coarse z-buffer being having a make-up of tiles, wherein each tile is associated a depth value, and wherein the depth value is used by**

applications to compare objects to be rendered so as to remove occluded objects. Rather, *Duluk* teaches an apparatus and method that perform comparisons on ***already known*** values for content queried from a z-buffer in a determination of keeping or discarding graphical content before rendering. *Duluk* does not explicitly or implicitly teach assigning depth values of a tile processed graphical display area as part of an effort of determining and discarding occluded graphical content.

As such, Duluk, alone or when combined with the prior art of record, simply does not teach or even suggest to one skilled in the use of a tiled coarse Z-buffer having associated depth values to realize occluded culling. Since *Duluk*, alone or when combined with the prior art of record, does not teach or suggest to one skilled in the art every limitation of the present invention, a *prima facie* case of obviousness has not been made. For these reasons, Applicants respectfully request that the obviousness rejection be withdrawn.

Differences from *Ouaknine et al.*

Ouaknine et al. disclose a computer 3D modeling and animation system that provides a user interface that allows users to make changes to 3D scene data while simultaneously allowing the author to view rendered images corresponding to those changes. The system provides tools associated with a 3D editing context as well as a rendered image that is automatically updated. In operation, the speed of updating the rendering is increased by identifying and re-rendering only portions of the region that require it. This may be achieved by breaking an image to be

rendered into tiles, some or portions of which may be subtended by the render region. The invention , in this case, may determine from the dimensions (coordinates) of the tiles, the particular scene modifications that are still current, and from the other scene data, the particular tiles that must be re-rendered.

In contrast to the inventions of Applicants' claims 1, however, the systems and methods taught by *Ouaknine et al.* **do not teach a system and methods that provide early occlusion culling wherein a display area is modeled as a coarse z-buffer being having a make-up of tiles, wherein each tile is <u>associated a depth value, and wherein the depth value is used by applications to compare objects to be rendered so as to remove occluded objects</u>.** Rather, *Ouaknine et al.* teach a system that allows for the more efficient editing of 3D images wherein images are broken down into tiles. The tiles are then processed during rendering to determine which portions of the image require modification (as a result of editing) and those that do not. *Ouaknine et al.*, however, do not explicitly or implicitly teach assigning depth values of a tile processed graphical display area as part of an effort of determining and discarding occluded graphical content.

As such, Ouaknine et al., alone or when combined with the prior art of record, simply do not teach or even suggest to one skilled in the use of a tiled coarse Z-buffer having associated depth values to realize occluded culling. Since *Ouaknine et al.*, alone or when combined with the prior art of record, do not teach or suggest to one skilled in the art every limitation of the present invention, a *prima facie* case of obviousness has not been made. For

these reasons, Applicants respectfully request that the obviousness rejection be withdrawn.

Differences from *Greene et al.*

Greene et al. disclose a hierarchical Z-buffer scan-conversion algorithm that rejects hidden geometry of a model, and exploits the spatial and temporal coherence of the images being generated. The method employs two hierarchical data structures, an object-space octree and an image-space Z-pyramid, in order to accelerate scan conversion. The two hierarchical data structures make it possible to reject hidden geometry while rendering visible geometry with the speed of scan conversion. In operation, an image-space Z-pyramid id employed. The z-pyramid offers the ability to make a determination whether a large polygon is hidden, making it unnecessary to scan-convert the polygon. This may be accomplished by combining four Z values (a 2x2) window at each level into one Z value at the next coarser level by choosing the farthest Z from the observer.

In contrast to the inventions of Applicants' claims 1, however, the systems and methods taught by *Greene et al.* **do not teach a system and methods that provide early occlusion culling wherein a display area is modeled as a coarse z-buffer being having a make-up of tiles, wherein each tile is <u>associated a depth value, and wherein the depth value is used by applications to compare objects to be rendered so as to remove occluded objects</u>.** ✓ Rather, *Greene et al.* teach an algorithm that processes graphical content to remove hidden elements of an object model and to render visible geometry at the speed of scan conversion. *Greene et al.*,

however, do not explicitly or implicitly teach assigning depth values of a tile processed graphical display area as part of an effort of determining and discarding occluded graphical content.

As such, Greene et al., alone or when combined with the prior art of record, simply do not teach or even suggest to one skilled in the use of a **tiled** ***coarse Z-buffer having associated depth values to realize occluded culling.*** Since *Greene et al.*, alone or when combined with the prior art of record, do not teach or suggest to one skilled in the art every limitation of the present invention, a *prima facie* case of obviousness has not been made. For these reasons, Applicants respectfully request that the obviousness rejection be withdrawn.

Claim Analysis:

Independent Claims 1 and 11-13:

Examiner has rejected independent claims 1, 11-13 as allegedly being obvious over *Aleksicy* and *Duluk*. Specifically, in Examiner's reading of the *Aleksicy*, the Examiner suggests that *Aleksicy* teaches a method for culling occluded objects from an image being rendered into a frame buffer, the method being performed by a host processor and comprising the steps of constructing a coarse z-buffer, the coarse Z-buffer being subdivided into a series of tiles each having an associated depth value. (Page 2 of Current Action citing to col. 2, lines 25-31, and Figure 1 of *Aleksicy*). Furthermore, Examiner suggests that *Duluk* teaches tile processing of graphical content. (Page 2 of Current Action).

Applicants respectfully disagree with the Examiner's reading of the *Aleksicy* and *Duluk*

references. Specifically, *Aleksicy* teaches **the determination of visibility of a pixel during rendering by determining the z-positioning information** of the **~~the on~~ object element.** Applicants are hard pressed to understand how one of ordinary skill in the art would equate the use of z-positioning information to determine pixel visibility to the tile processing of graphical content and association of depth information for tile processed graphical content to determine occluded content. (See Claims 1 and 11-14, and 18). It is apparent that these steps operate very differently and thus are not similar or the same.

Comparatively, *Duluk* teaches a system and method that perform a keep/discard decision on screen coordinate geometry using a z-coordinate buffer based on MCCAM structure. However, as described previously, *Duluk*, fails to teach the association of depth values to tile processed graphical content when realizing the keep/discard decision.

Since the use of z-positioning information does not constitute tile processing of graphical content and association of depth information to tile-processed information in determining occluded content, Applicants respectfully submit that *Aleksicy* and *Duluk*, alone or in combination, do not render the independent claims 1, and 11-13 obvious.

Independent Claims 14 and 18:

Examiner has rejected independent claims 14, and 18 as allegedly being obvious over *Greene et al.* Specifically, in Examiner's reading of *Greene et al.*, the Examiner suggests that *Greene et al.*, teaches all of the limitations of independent claims 14 and 18 of the present

application.

Applicants respectfully disagree with the Examiner's reading of the *Greene et al.* reference. Specifically, *Greene et al.* teach a hierarchical Z-buffer scan-conversion that rejects hidden geometry of a model and exploits the spatial temporal coherence of images being generated. When rejecting hidden geometry, the *Greene et al.*, invention employs a Z-pyramid that combines four Z values into one at each level by choosing the farthest Z from the observer. Applicants are hard pressed to understand how one of ordinary skill in the art would equate the use of Z-pyramid to eliminate hidden objects to the tile processing of graphical content and association of depth information for tile processed graphical content to determine occluded content. (See Claims 1 and 11-14, and 18). It is apparent that these steps operate very differently and thus are not similar or the same.

Since the use of z-positioning information does not constitute tile processing of graphical content and association of depth information to tile-processed information in determining occluded content, Applicants respectfully submit that *Greene et al.*, do not render the independent claims 14 and 18 obvious.

Dependent Claims 2-10, and 15-17:

Examiner has rejected dependent claims 2-10, and 15-17 as being allegedly obvious over *Aleksicy, Duluk, Ouakine et al.*, and *Greene et al.* for reasons set forth in the present action. Inasmuch as claims 2-10 and 15-17 depend either directly or indirectly from independent claims

1, 11-13, 14, and 18 , Applicants respectfully submit that they too patentably define over the prior art of record for the same reasons. Nevertheless, Applicants further submit that the *Aleksicy, Duluk, Ouakine et al.,* and *Greene et al.* references, nor any other prior art of record, whether alone or in combination, teaches or suggests the following subject matter:

Claim 2 – updating the depth values is performed synchronously as information in the frame buffer changes.

Claim 3 – updating the depth values asynchronously.

Claim 4 – constructing a surrogate volume for an object and comparing the nearest Z-value of the surrogate volume to the depth value of a tile that includes the surrogate volume.

Claim 5 – transforming the surrogate volume from an object-space to an eye-space.

Claim 6 – constructing a surrogate volume for an object, retrieving the greatest depth value from the set of tiles that are spanned by the surrogate volume, and comparing the nearest Z-value of the surrogate volume to the retrieved depth value.

Claim 7 – constructing a surrogate volume for an object, retrieving the greatest depth value from the set of tiles that are spanned by the surrogate volume, comparing the nearest Z-value of the surrogate volume to the retrieved depth value and transforming the surrogate volume from object-space to eye-space.

Claim 8 – constructing a lower resolution coarse Z-buffer, the lower resolution coarse Z-buffer subdivided into a series of tiles, each tile having an associated depth value, and updating the depth values of the lower resolution coarse Z-buffer using Z-information from the frame

buffer.

Claim 9 – constructing a lower resolution coarse Z-buffer, the lower resolution coarse Z-buffer subdivided into a series of tiles, each tile having an associated depth value, and updating the depth values of the lower resolution coarse Z-buffer using Z-information from the frame buffer, wherein each tile in the lower resolution coarse Z-buffer covers the same screen area as each tile tin the coarse Z-buffer.

Claim 10 – constructing a lower resolution coarse Z-buffer, the lower resolution coarse Z-buffer subdivided into a series of tiles, each tile having an associated depth value, and updating the depth values of the lower resolution coarse Z-buffer using Z-information from the frame buffer, wherein each tile in the lower resolution coarse Z-buffer covers the same screen area as each tile tin the coarse Z-buffer and wherein the tiles in the lower resolution coarse Z-buffer are overlapping.

Claim 15 – comparing the depth value of the surrogate volume with each of the spanning tiles, culling the objects whose surrogate volume has a depth value farther from the eye than the depth value of the tiles including the surrogate volume, and rendering the objects whose surrogate volume has a depth value closer to the eye than the depth value of at least one of the tiles including the surrogate volume or is equidistant to the eye with at least one of the tiles including the surrogate volume.

Claim 16 – subdividing the objects that are not occluded into smaller objects, and determining if the smaller objects are occluded.

Claim 17 – each coarse Z-buffer is replicated one or more times at different resolutions, each separate coarse Z-buffer spans the image using a different resolution, the number of tiles in the coarse Z-buffer of various resolutions remains constant, for lower resolution coarse Z-buffers, each tile covers a larger area of the image, for lower resolution coarse Z-buffers, the tiles overlap one another, center points of successive resolutions of tiles of the coarse Z-buffers are offset from the center points of preceding resolutions of tiles, lower resolution tiles of the coarse Z-buffer split the image between tiles with overlap, a higher resolution coarse Z-buffer splits the image between tiles with no overlap, and a host processor is allowed to select a resolution that corresponds to a size of any given object.

CONCLUSION

For all the foregoing reasons, Applicants respectfully submit that claims 1-18 patentably define over the prior art of record. Reconsideration of the present Office Action and an early Notice of Allowance are respectfully requested.

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